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WATERSHED PROGRAM EVALUATION

HONEY CREEK, IOWA

U.S. DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE AND SOIL CONSERVATION SERVICE ERS-204

FOREWORD

Honey Creek is a tributary of the Chariton River in Lucas County, Iowa. The Honey Creek Conservation Association was organized in 1949 through sponsorship of the Chariton Valley Conservation Association, incorporated under the State laws of Iowa. The Honey Creek Conservation Association, working with the Lucas County Soil Conservation District and using technical assistance from the Soil Conservation Service, informed local people of the nature of watershed protection and aroused their interest in establishing watershed improvements.

The U. S. Department of Agriculture Appropriation Act of 1954 provided funds for a pilot watershed protection program involving 65 projects throughout the United States. Honey Creek Watershed was one. Using the earlier findings and achievements of the local organizations, the Soil Conservation Service prepared a plan of improvements (Work Plan, 1954) to alleviate watershed problems arising from soil erosion and uncontrolled runoff. Local agencies helping to prepare the plan were the Lucas County Soil Conservation District, the Honey Creek Association, and the Lucas County Highway Department. Works of improvement were designed primarily for reducing sheet erosion, stabilizing gullies, and preventing sediment and inundation damages to property situated on the bottom lands.

The Department of Agriculture surveyed the pilot project to evaluate effects of the installed works of improvement. The surveys determined benefits to farmers and other groups from reducing runoff, erosion, and sedimentation, and the general effect on the area economy.

The evaluations also provided data and analyses relevant to improving planning procedures and techniques applicable to similar watersheds. Honey Creek Watershed is within the Iowa-Missouri Heavy Till Plain Land Resource Area, which contains several million acres. Throughout this area, problems of sheet and gully erosion are similar to those in Honey Creek.

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Washington, D. C. January 1965

SUMMARY

Annual benefits from an improvement project on Honey Creek Watershed in Iowa averaged $20,260 between 1955 and 1960, the evaluation period used in this study.

Evaluation of benefits was based on savings through the establishment of conservation measures, prevention of gully damage, reduction in sediment and floodwater damage to roads and bridges, intensified use of flood plains, and reduction in floodwater damage to crops.

An earlier estimate of benefits, in a 1954 Work Plan for the project, put average annual benefits at $34,480. However, the Work Plan estimate was a 50-year projection of benefits, predicated upon substantial long-run investments in land improvement and adjustments in land use. The 1955-60 appraisal was only of short-run benefits since the project started.

Adoption of conservation measures during the evaluation period was generally below what was recommended in the Work Plan. For example, there were only about half as many dual-purpose structures as recommended. Such structures stabilized gullies and impound water. However, water-storage capacity of the structures totaled only 182 acre-feet less than the 966 recommended.

Adjustments to extensive use of land were relatively greater on lands vulnerable to erosion than on more erosion-resistant land. Pasture improvement was accomplished on more than 800 acres, providing a substantial increase in forage to handle increased livestock numbers indicated by farm records for 1954 and 1960.

Estimated net land use adjustments in the watershed, calling for a gain in all cropland, did not occur during the evaluation period; however, rotations were shortened to include more corn in the annual cropping distribution. The increase in terrace systems, although only about one-half of the quantity recommended, reduced the amount of potential soil losses accompanying the shorter crop rotations. Based on records of sample upland areas, the average acreage of crops in 1955-60 declined 2-9 percent from the average of the preceding 4 years, corn and soybeans together increased 9.4 percent, hay declined 4.5 percent, and small grains dropped 17 percent. This general change in cropping intensity is in accord with the function of the installed dual-purpose gully structures. However, enough land-treatment measures should be adopted to furnish optimum control of sheet erosion and sedimentation in reservoirs established by the dual-purpose structures.

The improvement in wildlife habitat associated with the dual-purpose structures stimulated an increase in fishing and hunting. Local reports indicate an annual visitation of 1,650 fishermen to the reservoirs. Visits for hunting also increased approximately 1,060 during the evaluation period. The visitor days of fishing averaged 22 per surface-acre of water.

WATERSHED PROGRAM EVALUATION
HONEY CREEK, IOWA 1/

WATERSHED CHARACTERISTICS

The watershed of Honey Creek contains 9,120 acres; it is generally rectangular in shape, averaging 7 miles in length and 2 miles in width. Situated in the Iowa-Missouri Heavy Till Land Resource Area, the soils were developed from loess, glacial till, and alluvial derivations. The topography is generally undulating to rolling, with a few slopes of 10 percent adjacent to some of the streams. The mean annual precipitation is 31.7 inches and is fairly evenly distributed seasonally. During the period of weather record, the minimum of 13.77 inches occurred in 1910 and the maximum of 55.92 inches occurred in 1902.

Farming, or the servicing of farm activities, is the major occupation in the watershed. At the start of the project about 600 persons lived in the Village of Russell and 200 on farms. About 94 percent or 8,539 acres of the watershed lands were within operating farm units. Water for domestic and livestock uses was derived mainly from shallow wells and small farm ponds. Principal uses of farmlands were crops, 5,200 acres, and permanent pasture, 3,000. The major crops were corn and red clover-timothy hay. Cattle and hog feeding and raising were major enterprises on most farms. Consequently, only small quantities of crops were sold.

Major problems stemming from methods of land and water management occurred in the form of damages to highways and bridges, sheet erosion at the average rate of 7 tons per acre per year, and gully erosion. Appraisals of these annual damages, made in 1954 for project formulation, were transportation, $4,988; sheet erosion, $7,758; and gully erosion, $6,623.

Other losses--mainly agricultural--from inundation and sediment totaled $3,834. Frequent inundation of flood-plain crops caused an average damage of $1,761 and, in addition, limited the cropping intensity. The latter loss was estimated at $871. Taking into account all of the evaluated damages, the aggregate losses from floods, erosion, and sedimentation were estimated to average $15,214 per year.

Establishment of watershed improvement measures was started before the pilot watershed project was begun. The Lucas County Soil Conservation District in 1954 helped farmers prepare 58 conservation plans of 7,042 acres of watershed lands. Of the estimated total watershed improvement needs, approximately 20 percent of the stabilizing and sediment-control measures and 30 percent of the land-treatment measures had been installed. These accomplishments alleviated flood, erosion, and sediment problems, although their benefits were not evaluated. Damage evaluations in 1954 made allowance for the reductions provided by measures installed before the project was started.

1/ This report is the result of the joint efforts of the Iowa State Conservation's Office and the Engineering and Watershed Planning Unit, Lincoln, Nebr., of the Soil Conservation Service, and Resource Development Economics Division, Economic Research Service.

PROGRAM OF IMPROVEMENT

Planned Program and Estimated Benefits

The works of improvement planned for installation in the Honey Creek Watershed, their costs, and estimated benefits were set forth in the Watershed Work Plan, September 30, 1954. The recommended improvements consisted of two groups of measures: (A) flood prevention and (B) conservation of water and watershed lands. Works of improvement in the A group were to be installed with Federal project funds, while those in the B group were paid for by the farmers with financial assistance from other national programs. These measures and their total expected costs are shown in table 1.

In the A group of measures, stabilizing and sediment-control structures were planned for sites where vegetative control alone would not be adequate. Twenty-six of these structures were dual-purpose, combining floodwater detention and grade and gully control. They included a drop-inlet, earth-fill dam, and a restricted outlet conduit. The remaining 15 structures were principally the drop-spillway type, consisting of earth dams and a reinforced concrete wall with rectangular weir notch in the center of the upper part of the wall.

Subwatershed waterway improvement planned for 3.58 miles of small watercourses consisted of sloping banks, shaping the waterway, and establishing protective vegetation.

The remaining A measures planned included the sloping and seeding of eroding roadside and planting trees on 40 acres of critical runoff and sediment-producing areas.

The planned measures in the B group were formulated to provide conservation of water and land as a direct contribution to flood prevention. Terraces, field diversions, terrace outlets, and farm waterways were recommended to reduce runoff and erosion. These devices for regulating waterflow would protect the higher elevation fields by terraces and the lower fields by field diversions, while the constructed terrace outlets would carry runoff water to larger watercourses.

Establishment and improvement of vegetation on areas not included in the A group constituted the remaining B measures. Specific measures included pasture seeding of 470 acres of idle land and cropland and the liming, fertilizing, and reseeding of 1,450 acres of existing pasture. Wildlife plantings were planned for small areas of irregular shape that were inaccessible for farming. About 142 acres of partially denuded woodland and open land were to be planted to trees.

Land use adjustments were planned within the limits of land use capability classes. Summary of the recommended conversions indicated net gains of 234 acres of crops, 199 acres of woods, 20 acres of wildlife, and decreases of 386 acres of pasture and 67 acres of idle land. Crop rotations would also be adjusted in line with recommended conservation practices and land use

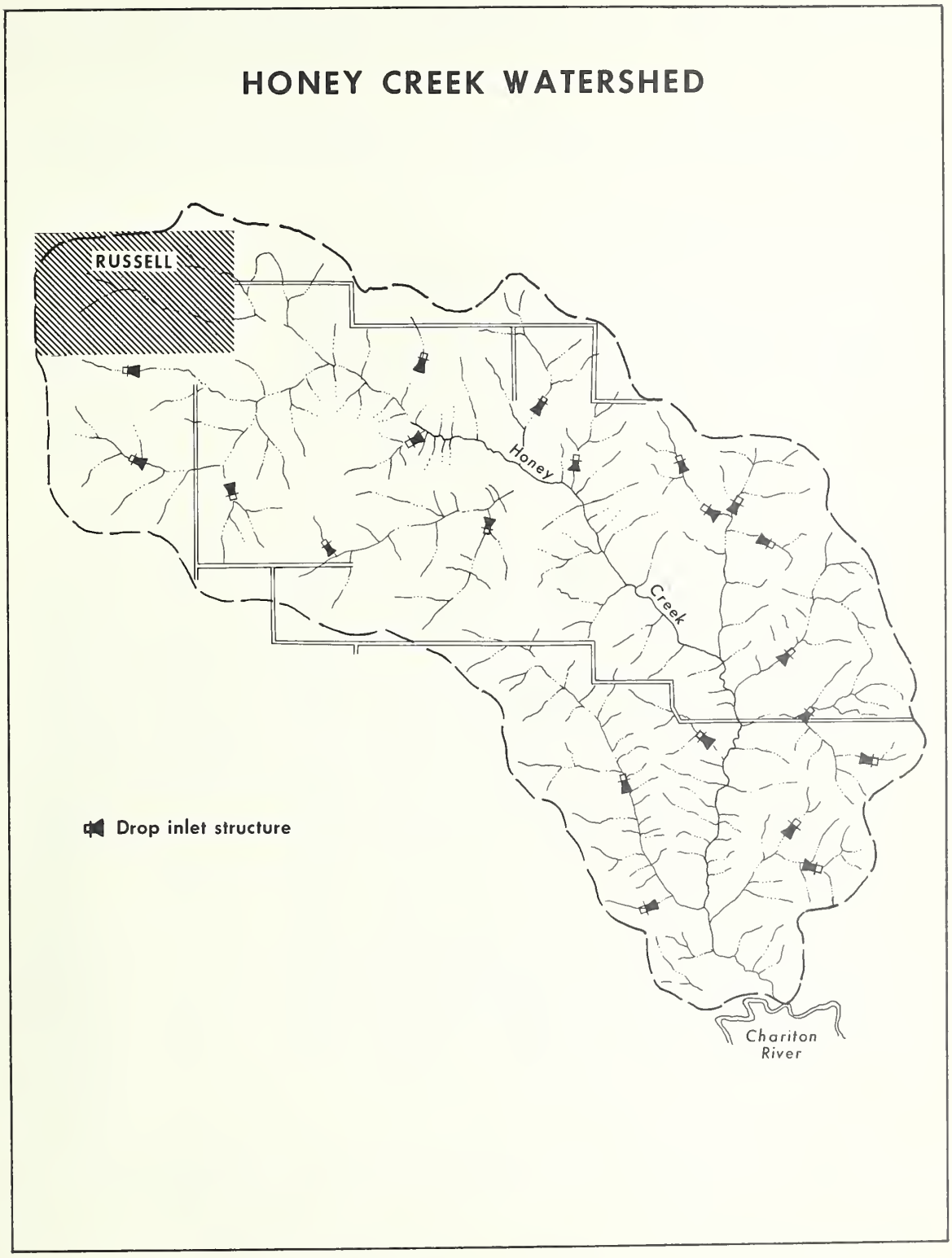

Figure 1

(Map to indicate location of installed dual-purpose structures, roads, drainage, and other watershed characteristics.)

Table 1.--Recommended works of improvement and estimated costs of installation, Honey Creek Watershed, Iowa, September 30, 1964

Recommended works of improvement	Unit of measure	Units	Total cost
			Dollars
A measures (flood prevention):			
Dual-purpose structures	No.	41	209,655
Subwatershed waterway improvement	Mile	3.58	6,368
Roadside erosion control: sloping	Mile	4.00	3,600
Roadside erosion control: seeding	Mile	14.00	5,600
Revegetation	Acre	40	4,260
Total			229,483
B measures (conservation):			
Terraces	Mile	113	23,900
Field diversions	Mile	8	3,120
Terrace outlets	Mile	5	1,730
Farm waterways	Acre	36	3,020
Pasture seeding	Acre	1,921	70,292
Wildlife area establishment	Acre	21	1,175
Tree planting (general reforestation)	Acre	142	5,985
Land use adjustments (including rotations):	Acre	3,500	14,540
Cropland to pasture	Acre	434	xxx
Cropland to woodland	Acre	42	xxx
Pasture to cropland	Acre	710	xxx
Pasture to woodland	Acre	115	xxx
Pasture to wildlife	Acre	16	xxx
Idle land to pasture	Acre	21	xxx
Idle land to woodland	Acre	42	xxx
Idle land to wildlife	Acre	4	xxx
Grazing protection to forest land	Acre	202	xxx
Technical assistance: open land	Acre	4,500	7,935
Technical assistance: forestry	Acre	160	1,340
Total			133,037
Grand total			362,520

capabilities. These adjustments, including the protection of woodland from grazing, would require 8 miles of fence relocation and 7 miles of new fence construction.

Estimated costs of installing the A and B groups of measures were $229,483 and $133,037, respectively. These estimates were exclusive of the costs of work plan development and program evaluation.

Estimated average annual benefits of the recommended program were indicated in the 1954 Work Plan in the following amounts:

Reduction of floodwater and sediment damage:	
Floodwater damage to roads	$ 880
Sediment damage to roads	2,330
Sediment damage to farm ponds	440
Infertile overwash and streambank erosion	40
Crop and pasture inundation	570
Indirect damage	370
Subtotal	4,630
More intensive use of flood plain	870
Conservation benefits	24,210
Reduction of sheet erosion	7,300
Reduction of gully erosion	5,620
Reduction of roadbank erosion	650
Total benefits	$43,280

Benefits from reduction in floodwater and sediment damage were expected to accrue mainly from reduced maintenance costs of roads and bridges. Benefits would also occur from growing more of the high-value crops such as corn and small grains on flood plains as a result of the reduced flood risk. Conservation benefits were evaluated by estimating the increased net income to farm owners and operators that would result from the application of the planned land-treatment measures. Sheet erosion benefits were calculated on the basis of preventing future yield losses, while gully erosion benefits took account of prevented land destruction and depreciation of lands bordering the gullies. The benefits listed above, when classified as agricultural and nonagricultural, would total $39,345 and $3,936, respectively. Agricultural benefits would be reflected over time in increased net income to farmers, while the nonagricultural benefits would consist primarily of lowered costs of transportation facilities.

Attainment of the estimated benefits, as stated in the Work Plan, depends on the cooperation of all local interests in installing and continously maintaining the recommended practices and measures. The recommended investments in land and water resources are substantial. How much they would enhance farm incomes is not known, since alternative farm plans for specific operating units were not budgeted or programmed. Also, accrual of some of the benefits, such as those from increased forage production, would depend upon adjustments in number and management of livestock. Public efforts to achieve supply-demand balance in agricultural commodities also would affect the attainment of estimated watershed project benefits.

A major concern of this report is to show economic changes that have occurred within the watershed and, insofar as feasible, to indicate their relationship to the works of improvement installed under the watershed program. Having direct bearing on this analysis is the extent to which the planned measures have been adopted.

Actual Program as Installed

The works of improvement installed under the watershed project are listed in table 2. A comparison with table 1 shows the divergence in measures planned and installed. In the A group of measures, 21 of the 26 planned dual-purpose structures were installed, and of the 15 planned drop spillway structures, 3 were installed. Storage capacity of the installed structures totaled 784 acre-feet in contrast to 966 acre-feet planned. The area of watershed above the structures totaled 43 percent in contrast to 46 percent as planned. Thus, the scale of flood prevention achieved was not greatly below what was planned. The few spillway structures installed were partly offset by an 89 percent increase in subwatershed waterways and a 228 percent increase in farm waterways. Although the planned system of structures was modified to meet local desires, the changes did not significantly detract from achievement of flood-prevention objectives.

The installed structures were maintained at a cost of about $50 each per year. This included mowing spillways and fills, cleaning trash racks, and routine inspections. Funds for cash expenditures were raised through a 1/2-mill tax levy by the Soil Conservation Subdistrict. Approximately $2,000 was raised, the levy was discontinued, and the tax receipts were invested in Federal Savings Bonds.

Of the B group measures installed, terraces were 55 percent less than planned; field diversions, 50 percent less; pasture seeding, 24 percent less; and tree planting, 81 percent less. However, there were twice as many terrace outlets as planned, more than twice as many farm waterways, and about seven times more wildlife areas. As a group, the vegetative measures established were about 20 percent less than planned. In the water-regulating group, the larger quantities of farm waterways and terrace outlets partially compensated for the lower quantities of field diversions and terraces.

Table 2.--Installed works of improvement and costs, Honey Creek Watershed, Iowa, 1954-60

Works of improvement	Unit of measure	Units	Total cost
			Dollars
A measures: (flood prevention):			
Dual-purpose structures	No.	24	231,320
Subwatershed waterway improvement	Mile	6.8	1/
Roadside erosion control: sloping	Mile	4.0	3,600
Roadside erosion control: seeding	Mile	9.0	3,600
Total			238,520
B measures: (conservation):			
Terraces	Mile	51	15,890
Field diversions	Mile	4	1,560
Terrace outlets	Mile	15	5,190
Farm waterways	Acre	128	4,540
Pasture seeding	Acre	1,468	65,030
Wildlife area establishment	Acre	166	9,290
Tree planting (general reforestation)	Acre	27	1,140
Land use adjustments	Acre	2,500	10,380
Technical assistance	Acre	4,500	7,930
Total			120,950
Grand total			359,470

1/ Included in cost of dual-purpose structures.

Planned land use adjustments would have increased cropland 4.5 percent and decreased permanent pasture 13.2 percent. However, net changes in land use from 1954 to 1960, based on studies of sample fields and sample farms, indicate a 14 percent decline in cropland and a 10 percent increase in pasture. The decline in cropland resulted from large decreases in hay and small grains but increases in corn and soybeans. Approximately 390 acres of cropland were diverted to the Soil Bank. The reduced acreage of land used for crops was partially responsible for the installation of a smaller quantity of terraces than anticipated in the original plan.

PROGRAM EVALUATION

The program evaluation was designed to measure the physical and economic effects of the installed works of improvement. Accordingly, gages were installed and surveys made to measure precipitation, streamflow, and waterborne sediment. Measurements were also made of the volume and rate of sediment accumulation in reservoirs and the changes in gully formation. These measurements for the period 1954 to 1960 provided a basis for estimating the effects of installed works of improvement on reducing the area of inundated lands, preventing of gullying, and reducing deposition. Resultant monetary benefits of these changes were computed from annual records of land use, production, and production practices on flood-plain lands and in the drainage areas of stabilized gullies. Evaluation procedures, analyses, and results are given below under the headings of hydrologic studies, geologic studies, and economic studies.

The results are not conclusive in several respects. The relatively short period of measurement, 6 years, is in sharp contrast to the 50-year period over which benefits were evaluated for determining economic feasibility of the watershed program. Long-term effects of sheet erosion are not observable during short periods. Although specific annual changes in land use, crop yields, and management practices are recorded, causal relationships with installed works of improvement were established through a process of inference. Analytical control of nonproject forces was only partially achieved. For these reasons, the evaluation findings should not be imbued with a high degree of predictability. Despite these reservations, the results indicate opportunities for re-examining planning techniques and procedures.

Hydrologic Studies

Precipitation and runoff data for hydrologic evaluations were obtained from records of 2 recording-type gages and a stream gage. The 2 rain gages have been in operation since March 1956 and March 1958, while the stream gage has been in operation since June 1952. The stream-flow gage is on Honey Creek 0.7 mile above the mouth of the creek, and records the flow from 13.2 square miles of drainage area, about 93 percent of the total watershed. A tabulation of all peak flows above a base discharge of 150 cubic feet per second during the growing season is shown in table 3. This table indicates there were 25 damaging floods during the growing season in an 8-year period (11 floods occurred during nongrowing seasons). The effect of the remedial structural program on each of the 25 floods is indicated. The floodwater-

Table 3.--Floods recorded during growing season 1/ at United States Geological Survey stream gage, Honey Creek Watershed, Iowa, June 1952-June 1960

Date of flood	Peak discharge			Area flooded	
	Actual	Original - no structures	Modified - all structures	Original - no structures	Modified - all structures
	C.f.s.	C.f.s.	C.f.s.	Acres	Acres
June 21, 1952	586	586	334	73	28
Aug. 11	170	170	97	8	0
Nov. 17	162	162	92	7	0
June 10, 1953	265	265	150	17	5
Apr. 26, 1954	245	245	140	15	4
July 31, 1956	265	417	237	45	15
Aug. 8	2/ 225	355	202	32	11
Apr. 3, 1957	238	400	228	41	14
Apr. 22	3/ 263	442	252	50	16
May 21	254	426	242	46	15
May 4, 1958	188	330	188	27	10
July 2	4/ 638	1,120	638	142	84
July 30	394	691	394	94	40
Sept. 9	184	323	184	25	9
Sept. 23	264	464	264	54	17
Nov. 17	246	432	246	48	15
Apr. 1, 1959	669	1,175	669	157	87
Apr. 20	450	790	450	108	51
May 21	4,100	7,200	4,100	315	276
July 1	240	421	240	45	15
Sept. 27	270	475	270	57	18
Oct. 6	170	298	170	21	8
Apr. 16, 1960	900	1,580	900	192	125
May 6	1,260	2,215	1,260	226	165
May 16	1,000	1,758	1,000	203	139
8-year total				2,048	1,167
Average annual				256	146

1/ April through November, inclusive.

2/ 36.5 percent of upland regulated by structures as of this date.

3/ 40.4 percent of upland regulated by structures as of this date.

4/ 43.1 percent of upland regulated by structures as of this date.

retarding features of the complete structural program reduced the peak flow of each flood by 43 percent, and for the 8-year evaluation period, the area of land flooded was also reduced 43 percent. However, the reduction in flooded area for a given flood is not directly proportional to the reduction in peak flow. A higher level of protection might have been obtained by more structures or by channel improvement, but the amount of floodwater damages did not warrant additional investment.

An evaluation was also made of the effect of the structural program over a longer period of time. For this analysis, a synthetic series of flood discharges was determined, and the corresponding area that would have been flooded with and without the structural program was computed. Based on these data, shown in table 4, the average annual acres of land flooded under original and modified conditions were derived. Accordingly, the respective areas flooded were 189 and 130 acres for all floods ranging from frequencies of 2 to 97 percent.

The structural program, now installed, regulates 43.1 percent of the total area above the stream gage. The runoff from this area is regulated by means of 21 drop-inlet dams with retarding features. Design characteristics of the drop-inlet dams and dates of completion are shown in table 5.

Estimates of the areas of land flooded for given peak discharges were based upon a series of 17 valley cross-sections at about 1/2-mile intervals on the main stem and on the major tributaries downstream from the structural measures. For each of these cross-sections, a stage-discharge relationship was developed for selected frequency discharges. The areas flooded for these frequencies were computed at each section.

The storm of May 21, 1959, subjected the watershed project to a severe test. This storm produced about 6 inches of rainfall in a 4-day period. Most of the rain occurred in a 6-hour period on May 20. A high percentage of runoff resulted because of the earlier rain on May 18. This storm produced a peak discharge of 4,100 c.f.s. at the USGS gage, as contrasted to an estimated 7,200 c.f.s. had the structural program not been installed. During this flood, only one structure had its emergency spillway go into operation. This structure was designed on a 25-year basis for emergency operation, while all others had a 50-year design before emergency operation was intended. The area flooded during the storm was estimated to be 276 acres, while 315 acres would have been flooded without the structural program. This represents a 12-percent reduction in area flooded.

Geologic Studies

Geologic studies were made in an effort to determine (1) the effects of dual-purpose structures and their waterways on land losses, (2) the rate of reservoir sedimentation, (3) changes in stream-borne sediment, and (4) changes in sheet erosion.

Table 4.--Area flooded for synthetic series of floods, Honey Creek Watershed, Iowa

Frequency of flood	Peak discharge		Area flooded	
	Original - no structures	Modified - all structures	Original - no structures	Modified - all structures
	C.f.s.	C.f.s.	Acres	Acres
50-year	5,090	2,900	291	251
10-year	3,280	1,870	260	208
5-year	2,610	1,490	242	183
2-year	1,620	920	193	128
1.1-year	800	455	110	52

Table 5.--Design characteristics of dual-purpose structures, Honey Creek Watershed, Iowa

Structure number	Drainage area	Outlet pipe size	Maximum outflow	Date completed
	Acres	Inches	C.f.s.	
A-2	178	24	54.0	Oct. 6, 1956
A-3	210	24	54.0	May 6, 1955
A-4	227	18	28.0	Aug. 17, 1957
C-3	51	18	31.0	May 24, 1955
C-7	256	24	61.5	Dec. 2, 1954
D-4	94	18	29.0	May 31, 1955
D-6	143	18	30.0	June 17, 1955
E-1	306	24	53.0	July 18, 1955
F-1	776	42	211.4	Nov. 5, 1955
F-2	37	18	32.0	Nov. 7, 1955
G-10	108	18	29.7	Nov. 23, 1955
H-2	181	18	33.7	Oct. 2, 1954
H-3	183	18	30.0	Sept. 2, 1954
H-4	70	18	28.3	Aug. 10, 1954
I-1	322	30	79.6	Nov. 14, 1955
J-3	170	24	59.0	May 23, 1956
J-4	65	18	31.0	June 22, 1956
K-1	50	18	32.0	Sept. 22, 1956
K-4	106	18	32.0	Sept. 10, 1956
M-4	110	18	31.0	June 11, 1956
H-2A	1/	24	54.0	Oct. 2, 1954

1/ The 89-acre drainage area of this structure is included in the drainage area indicated for structure No. H-2. Since no other structures are in series, the net area controlled by all of the structures is 3,643 acres.

Rates of land losses from gullying were evaluated in the drainage areas of 5 drop-inlet dams with retarding features. These subwatersheds, totaling 1,809 acres, are representative of erosion conditions upstream from all of the Honey Creek Watershed structures. Data for the analyses were obtained from several sources. Notes of field surveys for the 1954 Work Plan provided some information on location and height of overfalls and the width and depth of gullies. Aerial photographs at various intervals provided a way to estimate rates of gully growth. Farmers in the watersheds and on-site inspection furnished additional information.

The original field notes and observations show that the greatest gully depths were about 8 feet. These depths were in areas now within the impoundments. In many drainageways upstream from the structures, the depth of floodwater-deposited soil is about 2 to 4 feet, overlying a heavy, dense material. These drainageways are usually quite wide and rather wet, providing good sites for heavy stands of grass. This swamp-type grass has a dense root system, apparently spreads very readily, and re-establishes itself very easily when eroded and transported to a new location.

The character of the soil conditions and the vegetation tend to limit the depth and width of many gullies to around 2 to 4 feet deep and from 2 to 10 or 12 feet wide. In some waterways where these conditions do not exist, the gullies may be somewhat deeper and tend to widen considerably faster than in the swamp-grass areas. But even under these conditions, the gullies are not very wide or deep.

For the sample areas as a whole, reduction in land loss and depreciation were computed to be 0.235 acre and 1.68 acres, respectively, per year. Expanded to the total watershed area protected, the annual rates are 0.54 acre of land loss and 3.86 acres of land depreciation.

Surveys of reservoir sedimentation for each of the 5 sample structures were made in the falls of 1958 and 1959 and in the winter of 1961. Results of these surveys and relevant features of the reservoirs and their drainage areas are shown in table 6.

The combined drainage area of the 5 reservoirs is 1,809 acres. They are considered representative of the entire upland watershed area of 8,448 acres upstream from the USGS stream gage and suspended load station (a station to measure sediment suspended in streamflow). The area controlled by the sample structures comprises 49.6 percent of the total area controlled by the 21 structures listed in table 5 and 21.4 percent of the total area upstream from the USGS stream gage.

The range method was used in making the surveys. The last of three sedimentation surveys was completed in January 1961. At that time, the period of sediment accumulation varied from a minimum of 3.4 to a maximum of 5.5 years. Since these data are based upon sediment accumulation during relatively short periods of time, they may not be representative of long-term conditions.

Table 6.--Summary of findings: Reservoir sedimentation surveys of 5 sample structures, Honey Creek Watershed, Iowa, January 1961

Item	Unit	Structure				
		A-2	A-4	E-1	F-1	I-1
Total drainage	Sq. mile	0.219	0.355	0.478	1.213	0.503
Date storage began	Year	1956	1957	1955	1955	1955
Storage:						
Conservation pool	Acre-ft.	15.53	26.72	29.10	39.64	30.32
Flood control	Acre-ft.	37.18	38.21	113.09	144.35	75.58
Total	Acre-ft.	52.71	64.93	142.19	183.99	105.90
Surface area:						
Conservation pool	Acre	2.56	5.65	5.38	8.15	4.88
Flood control	Acre	6.46	5.35	11.08	15.84	8.31
Total	Acre	9.02	11.00	16.46	23.99	13.19
Length of watershed	Mile	0.833	0.795	0.900	1.799	1.098
Average width of watershed	Mile	.334	.447	.531	.674	.458
Range in watershed elevation	Foot	39	58	73	108	92
Mean annual runoff	Acre-ft.	70.31	89.67	120.87	306.52	127.19
Accumulative sediment deposits, January 1961:						
Total	Acre-ft.	.550	1.590	3.260	5.022	2.174
Annual average	Acre-ft.	.129	.460	.590	.970	.420
Annual average per square mile 1/	Acre-ft.	.489	1.36	1.31	.820	.872
Annual average per square mile 2/	Ton	703	1,955	1,883	1,179	1,251
Annual average per acre	Ton	1.10	3.05	2.94	1.84	1.95
Storage loss, percentage of total capacity:						
To January 1961	Percent	1.04	2.45	2.29	2.73	2.05
Annual average	Percent	.24	.71	.41	.53	.40
Storage loss, percentage of conservation pool capacity:						
To January 1961	Percent	3.61	5.92	11.64	12.10	7.07
Annual average	Percent	.85	1.73	2.03	2.45	1.38

1/ Based on sediment-contributing area only.
2/ 66 pounds per cubic foot, as determined by sediment samples.

Rates of sediment accumulation varied from 0.489 to 1.36 acre-feet per square mile per year, with an average of 0.77 acre-foot for the 5 reservoirs. Except for 1 reservoir, the annual rate of sediment accumulation in acre-feet per square mile varied inversely with the size of subwatershed. The rates of accumulation varied from 1.10 to 3.05 tons per acre per year, with an average of 2.18 from the sediment contributing area.

Sediment trapping efficiency for each of the 5 structures was estimated at approximately 96 percent. This means that the actual sediment yield to the reservoir sites is somewhat higher than the quantities shown above, and that approximately 4 percent of the sediment reaching a structure passes through it and continues downstream.

Based on this trap efficiency, the 21 structures, with a combined drainage area of 3,643 acres, will trap approximately 7,620 tons of sediment per year. Approximately 320 tons of sediment per year will pass through the structures and continue downstream; however, without these structures, approximately 7,940 tons per year would move past the structure sites.

Average annual capacity losses of conservation pools range from 0.85 to 2.45 percent per year for the 5 sample structures. Average annual capacity losses of total storage range from 0.24 to 0.71 percent per year. In 2 reservoirs there was movement of sediment from the retarding pool to the conservation pool. The average annual loss of conservation pool capacity is 1.88 percent per year. Two of the structures have had losses of over 2 percent per year. Although these computations indicate the possible loss of the entire conservation pool capacity in less than the normal design period of 50 years, these data are short-term. Future application of land treatment measures will reduce the quantity of sediment reaching the structures.

Suspended load measurements of sediment have been made by the USGS at a gaging station in the Honey Creek Watershed 0.7 mile upstream from its mouth, but downstream from all the dual structures. Measurements started in June 1952. The drainage area upstream from the gage is 13.2 square miles.

Some of the data used in this analysis have been previously published; other data are only preliminary and subject to revision (table 7).

Installation of the last of the 21 dual structures was completed in August 1957. Since only a small amount of sediment passed the gage in August and September 1957, it can be assumed that suspended load measurements after October 1, 1957, probably include only sediment coming from the uncontrolled area downstream from the structures.

From October 1, 1953, to September 30, 1961, the average annual load measured at the station was 4,509 tons. For the 5-year period before the structures were completed, the average annual load was 2,233 tons. For the 4-year period following completion, the average annual load was 7,355 tons. A reduction in suspended sediment flow would be expected after the structures were completed. Although no studies have been made of rainfall records, measurements at the gage show that runoff during each of the 4 years between

Table 7.--Stream-borne sediment in Honey Creek, Iowa, June 1, 1952, to September 30, 1961 1/

Item	Unit	Period 2/									
		1952	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58	1958-59	1959-60	1960-61
Drainage area	Sq. mile	13.8	13.8	13.8	13.8	13.2	13.2	13.2	13.2	13.2	13.2
Total load per year	Ton	5,154	5,098	1,268	658	1,802	2,339	1,827	14,265	8,462	4,866
Sediment yield per square mi.	Ton	374	369	92	48	137	177	138	1,080	641	369
Mean daily load per year	Ton	44	14	3.5	1.8	4.9	6.4	5.0	39.1	23.1	13.3
Maximum daily load:											
Time	Date	6/21	3/30	4/26	7/9	8/1	5/21	7/2	5/21	5/16	3/6
Volume	Ton	2,500	970	940	202	500	550	380	6,300	1,500	850
Maximum daily concentration:											
Time	Date	6/20	6/8	4/26	7/9	7/4	6/14	5/4	5/21 6/30	5/16	3/6
Volume	Ppm	9,840	1,500	2,400	2,320	1,600	1,780	750	1,100	1,500	1,600
Runoff	Acre-ft.	---	4,400	298	918	755	1,600	4,720	10,920	11,670	5,960

1/ Data from USGS station near mouth of Honey Creek (see page 8). Some of the data are preliminary and subject to revision.

2/ October through September for years shown, except first (1952) when data are for June through September. Last of 21 dual-purpose structures was completed in August 1957; storage began August 19, 1957.

October 1, 1957, and September 30, 1961, exceeded that of any single year of measurement prior to October 1, 1957. Also, table 3 shows more floods occurred in the 4-year period following October 1, 1957, than occurred prior to that date. In May of 1959, 8,800 tons of sediment passed the gage during a 2-day period. This was 62 percent of the total load during 1959 and approximately 21 percent of the total load passing the gage during the 9-year period. These data may tend to explain to some extent the greater measured sediment load following the installation of the dual-purpose structures than before.

The average annual measured load was 339 tons per square mile for the total period and 557 tons per square mile annually for the last 4 years of the period. Since the structures have a trap efficiency of approximately 96 percent, practically all of the sediment measured at the gage came from the area downstream from the structures.

Soil losses by sheet erosion were computed for 2 of the 5 sample subwatersheds. The combined area of these 2 subwatersheds is approximately 5 percent of the upland area upstream from the USGS stream gage and suspended load station.

Computations were made for only those soil survey delineations showing slopes in excess of 2 percent (up to 11 percent), since slopes of 2 percent or less generally do not need special erosion control measures. The procedure used in computing sheet erosion losses evaluates soil loss as a function of soil erodibility, slope, length of slope, precipitation, cover, management, and conservation practices.

Measurement of the relevant variables for the preproject period 1951-54 and for the postproject year 1960 was secured from precipitation records, soil survey maps of the subwatersheds, field observations, and interviews with local technicians and landowners.

During the preproject period on lands having greater than 2 percent slopes, 57 percent of the area had soil losses less than the allowable rate of 3.5 tons per acre.[2/] In 1960, only 27 percent of the area had soil losses less than 3.5 tons per acre. On the remaining lands for the preproject period and 1960, respectively, the annual rates of soil loss per acre averaged 7.33 tons and 6.97 tons.

A reduction in sheet erosion would have been expected to follow the increased application of land-treatment measures; however, the evaluations reveal the opposite result. Although no studies were made of the rainfall

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2/ Held and Timmons (Soil Erosion Control in Process in Western Iowa. Iowa State College Res. Bul. 460, August 1958) explain the allowable rate of soil erosion: "The concept of a permissible rate of soil erosion is a physical rather than an economic concept. It is that rate of loss at which the level of fertility can be maintained by offsetting soil losses with practices that increase fertility. It has also been assumed, but has not been proved, that gully formation commences or accelerates at any higher rate of soil loss."

records, streamflow measurements indicated unusually heavy runoff in the postproject years. Had the rainfall patterns in the 2 periods been more comparable, the differences in computed erosion rates would have been far less.

Cross-sections and profiles were made of channels for distances of several hundred feet downstream from dual-purpose structures to detect changes resulting from the installations. Surveys in November 1957 and January 1961 indicated relatively little change in channel conditions. The most significant change occurred where there was some seepage in the channel and livestock had been permitted access to it. In this case, there was some degradation of the channel for a short distance downstream from the structure outlet; however, it was not considered serious and about 500 feet downstream from the outlet there was little indication of either aggradation or degradation.

Economic Studies

The major study areas for economic analyses included (1) the flood plains of Honey Creek and major tributaries, (2) the drainage areas above 5 dual-purpose structures, and (3) lands adjacent to the creeks on which the structures are located, but below the dams. These study areas are referred to as flood plains, lands above structures, and lands below structures, respectively, unless otherwise noted. Actually, a small percentage of the land in the third category is flood plain, but it is excluded from the first.

These 3 study areas are affected by the project in different ways. Generally, the lands above structures are protected from further gullying and are provided stabilized watercourses for terrace construction. Interrelated land-treatment measures permit the use of more intensive crop rotations. Lands below the structures are given protection from inundation, sedimentation, bank cutting, and erosion, and are also provided with stabilized watercourses for terrace construction. Flood-plain lands are similarly affected, but the protective works of improvement are more widely distributed throughout the watershed. The watershed lands surveyed include 1,712 acres above structures, 424 acres below structures, and 418 acres of flood plain. 3/ Together, they represent 30 percent of the farmland in the watershed.

For these sample areas, data on annual use, management, and production in 1951-60 were obtained, by fields, from farmers and records of the Lucas County Soil Conservation District. Approximately 190 fields operated within 50 farm units were included in the areas studied. In addition, general data on land resources, production, and income were inventoried for 1954 and 1960 on 22 sample farms.

3/ A slight descrepancy exists between the surveyed area above the structures and the area indicated in table 6. This is due to minor variations in field delineations from the boundaries of the sample drainage areas.

Summaries of data and analyses are concerned with estimating major project consequences, such as:

1. Reduction in floodwater and sediment damages

2. Intensification of land use on the flood plain

3. Reduction of gully damages

4. Conservation benefits on farmlands from land treatment

Items 1 and 2 are treated together under "flood-plain benefits." Project effects on reducing losses from gullying are discussed under "dual-purpose structures." The latter evaluations also include costs of works of improvement and prorated shares of the benefits from reducing floodwater and sediment damages. Item 4 is treated under "conservation benefits."

Flood-Plain Benefits

Land use, yields, and value of production on flood-plain lands are shown by years in table 8. Year-to-year changes in value of production reflect differences in land use and yields only, since prices are held constant. 4/ These values, however, do reflect the impacts of flooding and the numerous nonflood variables on land use and yields. If we remove the factor of yield variability as well as the price variable, by using average annual yields, the annual values of production should then reflect the changes in land use only. Such annual values of production indicate a steady annual gain attaining 32.6 percent by 1959. In 1960, however, the increase dropped to 21.2 percent. The average increase during 1955-60 was 18.9 percent or $2,275 higher than the base period. This trend might partially be explained by the avoidance of flood risk. The complexities involved in removing the effects of the other variables involve analyses of data beyond the resources available for the project evaluation. Yet, further credence in these trends as an indicator of the effect of flood risk reduction may be justified by comparing them with trends in production on the upland fields. As will be noted later in this report, value of production on the upland sample areas increased by much smaller amounts than value of production on flood-plain lands. Allowing for additional production costs associated with the more intensive land use, 40 percent or $880 of the increased gross value may be credited as a benefit from the reduction of flood risk.

Further indication of the influence of flood protection on land use also is observable from other data. For example, a farmer owned a 32-acre field of flood plain. From 1951 to 1955, before project installation, he used the field only for pasture. During the following 5 years he converted it to crops. This land was severely scoured by flooding before 1955. Before the conversion in use, approximately $1,000 was invested in clearing and leveling. Reduction in flood risk was reported by the farmer as the reason for making the change.

4/ Agricultural Price and Cost Projections. U. S. Dept. Agr., Agr. Res. Serv. and Agr. Mktg. Serv., Sept. 1957.

Table 8.--Annual land use, average yields, and value of production on flood plains, Honey Creek Watershed, Iowa, 1951-60

Item	1951 to 1954	1955	1956	1957	1958	1959	1960	Average 1955-60
				Acres				
Land use:								
Corn	88	117	109	121	133	155	134	128
Soybeans	16	8	22	22	29	3	3	14
Small grain	6	1	7	0	9	0	6	4
Hay	12	8	9	7	2	19	22	11
Pasture	253	248	220	206	173	202	209	210
Idle and soil bank	43	36	51	62	72	39	44	51
Total	418	418	418	418	418	418	418	418
				Bushels				
Average yields:								
Corn	52	60	61	62	65	47	43	56
Soybeans	28	25	21	26	21	20	16	22
Oats	37	25	25	-	9	-	25	21
				Tons				
Hay	1.9	2.0	1.6	1.8	2.0	1.5	1.0	1.6
				Animal Unit Month				
Pasture	2.6	2.6	2.8	3.0	2.5	2.7	3.6	2.9
Production value (long-term price):				Dollars				
All crops	8,027	10,637	10,817	12,120	13,696	10,860	8,693	11,137
Pasture	3,453	3,385	3,234	3,244	2,271	2,863	3,950	3,158
Total	11,480	14,022	14,051	15,364	15,967	13,723	12,643	14,295
Production value (long-term prices and average yields 1955-60):								
All crops	8,169	9,869	10,079	10,867	12,191	12,871	11,382	11,137
Pasture	3,851	2,775	3,348	3.135	2,633	3,074	3,181	3,158
Total	12,020	12,644	13,427	14,002	14,824	15,945	14,563	14,295

Reduced flood damages during the evaluation period were estimated through analyses of hydrologic and economic data applicable to the watershed conditions from 1956 to 1960. Installation of the planned structural measures was essentially complete in 1956. For each flood, hydrologic evaluations determined the area of land inundated (modified area) and the area of land that would have been flooded in absence of the installed project improvements (original area). The floods from 1956 to 1960 during the growing season and the areas inundated were shown earlier in table 3.

Flood damages to crops and reductions in losses due to the project were based on the differences in crop yields obtained on flooded and nonflooded fields. Such comparative data were obtained only for 1958, 1959, and 1960, when serious flooding occurred. A summary of the average yield differences in bushels per acre indicated the following:

	Flooded yields	Flood-free yields
Corn, 1958	43	70
Corn, 1959	43	69
Corn, 1960	48	60
Soybeans, 1958	12	25

These yields represent farmers' estimates obtained during the winter following the crop season. The yields of inundated crops reflect the impacts of more than one flood each year, since farmers' reports did not permit a separate appraisal of the effects on yield of each inundation.

Annual damages per acre of all land flooded, based upon the differences in flood and nonflood yields, were $14.68 in 1958, $14.58 in 1959, and $6.05 in 1960. These damage rates are composites of all of the crops flooded, reflecting the ratio of each crop to the total. The lower average damage per acre in 1960, in contrast to the 2 previous years, may be attributed to the absence of summer floods.

The total damage prevented for each year was computed as the product of the average damage per acre and the number of acres on which flooding was prevented by the project measures. 5/ For 1956-60, damages prevented totaled $3,110, averaging $622 per year. They ranged from $188 in 1957 to $1,086 in 1958.

5/ The validity of this procedure rests on assumptions which, in view of other circumstances, seem reasonable. First, the distribution of land use on the protected flood plain is assumed to be the same as on the flooded land. Second, differences in depth and velocity of floodwater are not sufficiently great to produce differences in the rates of floodwater damage. No allowance in the rates of damage was made for reduced costs of production due to lower yields or no yields. Such an allowance seemed unnecessary due to the fixed nature of several of the machinery and labor practices involved and, in some instances, the additional time required for production practices.

Including the annual benefit of $880 from more intensive use of floodplain lands due to the reduction in flooding, the total flood prevention benefits averaged $1,502 per year. These benefits do not include the reductions in damages to State, county, and farm roads.

The watershed highway system, including 30.2 miles of county roads and 7.5 miles of farm roads, is subject to flood damage through inundation and sediment. Prior to installation of the watershed project, these losses were estimated by road officials to average $2,297 per year from inundation and $2,691 per year from sedimentation.

The size or magnitude of a flood is expressed as the expected frequency of occurrence. During 1955-60, four floods occurred which have an expected frequency of less than once in 2 years. However, many of the floods which occurred have an expected frequency of more than once a year. The installed works of improvement mitigated the damaging effects of these floods by reducing the area flooded, lowering the runoff velocity, and decreasing the volume of waterborne sediment.

Peak discharge of the May 21, 1959, flood would have been 75 percent greater had the structural and related measures not been installed; 14 percent more land would have been flooded; the depths of floodwater and velocities would have been greater; and the volume of sediment impeding roadways, culverts, and bridges substantially larger. A damage survey shortly after this flood disclosed highway losses to be considerably lower than those occurring from similar floods in earlier years. Honey Creek overflowed extensively and topped county road fills in 4 locations without doing much damage. Gravel surfacing was not scoured to a noticeable degree and only one instance of undercutting of earth fill was observed. Outside of the Honey Creek Watershed, however, severe damages occurred where the storm volume and intensity were similar. In the headwaters of Cedar Creek, north of Honey Creek, floodwaters overtopped road fills and in some instances completely removed the gravel surface and extensively cut the fills.

Flood prevention benefits through reduction of damage to transportation facilities were estimated on the basis of the lowered costs of repair and maintenance reported by highway officials. The average annual benefits may be credited as $800 from reduction in flooding and $1,700 from reduced sedimentation, aggregating $2,500.

Dual-Purpose Structures

Five of the installed dual-purpose structures were selected to study their effectiveness in achieving the purposes for which they were designed. Three specific purposes of the structures were considered. Their influence in reducing off-site flood and sediment damages was appraised under the floodplain discussion elsewhere. More significant, however, is the role of the structures in providing outlets for terrace systems by stabilizing the main waterways. A third purpose of the structure is to prevent land loss and depreciation by halting further advances of the gully system.

About half the planned terrace systems were installed between 1955 and 1960 on the lands protected by the sample structures. Thus, about half the increased crop returns expected from additional terracing represents a future potential benefit.

The trend in land use is toward lesser acreages of crops and correspondingly more pasture, wildlife, and Soil Bank reserve. This is indicated in table 9, which shows the proportion of land in major uses for the 1955-60 period. Although total crops declined from 71.9 percent of land area in 1955 to 60.5 percent in 1960, the intensity of cropping increased, as evidenced by the increasing proportion of all cropland in corn and soybeans. In view of this change, it would seem that the additional terrace systems constructed were consistent with land use changes and erosion control objectives and that they will promote higher crop yields than otherwise obtainable.

The increased yields of corn during the 1956-60 period, as shown in table 10, should not be attributed to the effects of the project measures alone. Other variables affect yields, but available data do not permit measurements of their quantitative effects. Construction of the additional terrace systems in the sample areas was completed in 1957. Therefore, the higher yields in the succeeding years might be partially credited to the investment in watershed improvements.

Research on the effects of terraces on crop yields indicates that yields under some circumstances may be lower for a year or two following construction but, in the long run, slightly higher yields may be expected. 6/ A study of crop yields in Iowa indicates that on Grundy silt loam soils, erosion-control practices will increase the long-term average yield of corn by 3 bushels per acre. 7/ This report shows corn yield differentials of 4 bushels and 2 bushels due to erosion control when raised under low and high management levels, respectively. No appreciable differences in yields due to erosion-control practices are indicated for other crops. A recent study in northeastern Kansas, on Grundy silty clay loam soils, indicates somewhat similar results. 8/ This report shows the major economic effect of terraces and accompanying practices to be the prevention of long-run yield declines. It does indicate, however, that present corn yields average 1 to 2 bushels per acre higher on terraced lands (5-7 percent slope). Similarly, hay yields are 0.1 ton higher.

6/ Economic Evaluation of Use of Soil Conservation and Improvement Practices in Western Iowa. U. S. Dept. Agr. and Iowa Agr. Expt. Sta. Tech. Bul. 1162, June 1957.

7/ Shrader, W. D., Schaller, F. W., Pesek, J. T., Slusher, D. F., and Riecken, F. F. Estimated Crop Yields on Iowa Soils. U. S. Dept. Agr. and Iowa Agr. Expt. Sta. Special Rpt. 25, April 1960.

8/ Micheel, Charles C., and Nauheim, Charles W. Economics of Soil Conservation, Northeastern Kansas. U. S. Dept. Agr. and Kansas Agr. Expt. Sta., Agr. Econ. Rpt. 101, Dec. 1961.

Table 9.--Proportion of land in major uses, in all upland sample areas, Honey Creek Watershed, Iowa, average 1951-54, annual 1955-60

Land use	1951-54	1955	1956	1957	1958	1959	1960
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
All crops	70.7	71.9	69.6	71.7	65.6	64.3	60.5
Corn and soybeans	25.0	24.4	24.6	34.2	29.6	25.4	35.2
Small grain	18.7	22.1	14.7	14.5	13.2	12.9	2.7
Hay	27.0	25.4	30.3	23.0	22.8	26.0	22.6
Noncrop	29.3	28.1	30.4	28.3	34.4	35.7	39.5

Table 10.--Average yields of selected crops, all sample upland areas, Honey Creek Watershed, Iowa, average 1951-54, annual 1955-60

Crop	Unit	1951-54	1955	1956	1957	1958	1959	1960
Corn	Bushel	50.7	52.6	58.2	64.8	68.8	64.4	67.0
Oats	Bushel	44.9	50.0	20.4	39.6	39.7	23.9	51.8
Soybeans	Bushel	27.0	24.3	24.6	29.1	28.4	25.4	27.5
Hay	Ton	2.3	2.3	2.2	2.5	3.1	3.0	1.8
Pasture	Animal unit mo.	2.9	2.8	2.9	2.8	2.6	3.2	3.7

A conservative appraisal of the benefits from installing terrace systems should result from crediting increases of 3 bushels of corn and 0.1 ton of hay to future yields. Since approximately 50 percent of the recommended terrace systems were installed, the benefit appraisal is based on one-half of the corn and hay crops. Average annual acreages for 1955-60 were used for this calculation. The average annual value of the increased production in the 5 sample areas totals $1,287. This value is net of the increased cash costs of harvesting.

Benefits from prevention of land damage through stabilization of gully erosion were computed on the basis of crop and forage production which otherwise would not have been produced. Annual rates of land loss and depreciation in each of the sample areas that would have occurred if the project measures had not been installed were estimated by geologic studies. Depreciated lands would have resulted from the occurrence of closely spaced small gullies isolating intervening areas. It is estimated that such lands in rotation crops would shift to pasture. The underlying principles of the monetary appraisal of the benefits are similar to those implicit in the land damage evaluation procedure used in watershed planning. 9/ Land damage appraised by this method is composed of losses in (1) net income to land; (2) returns to labor, capital, and management during a 10-year adjustment period; (3) real estate tax base; and (4) social values not reflected in net land returns.

The area of land ultimately affected by gully erosion is shown for each sample area in line 1, table 11. This is equal to the total drainage area above the dual-purpose structure. Line 2 indicates the rates of land damage in acres per year.

The loss of production prevented (line 4, table 11) is the product of the rate of land damage and the gross income per acre (lines 2 and 3). Gross income is the average for the years 1956 to 1960, inclusive, and is valued in terms of long-term projected prices. The adjusted gross income represents returns after allowing for cash operating costs (line 5). Lines 7, 8, and 9 indicate the portions of adjusted income attributed to (1) land; (2) real estate taxes; and (3) family labor, capital, and management, respectively. The present worths of the annual benefits from preventing reductions in these incomes are shown in lines 10, 11, 12, and 13.

The benefit to labor, capital, and management (line 10), as calculated, assumes limited opportunities for use of these inputs when land damage occurs. It further assumes a 10-year period for adjustments in farm organization and practices to compensate for the displaced inputs. Potential adjustments may include intensification of enterprises, expansion of farm size, and off-farm employment.

To estimate the total benefits attributable to each of the sample areas, flood-prevention benefits on the flood-plain lands of Honey Creek were prorated according to the ratio of the area controlled by each sample structure to the total watershed area controlled. A summary of the several types of evaluated benefits credited to the dual-purpose structures, including (1) flood-damage reduction and land-use change on flood plains, (2) prevention of land damage by gullying, and (3) increased yields due to installation of terrace systems, is shown for each sample area in table 12.

9/ Economic Guide for Watershed Protection and Flood Prevention. U. S. Dept. Agr., Soil Con. Serv., March 1964.

The investment in structural measures and terrace systems for controlling gullies in the sample areas amounted to $80,115, of which 98 percent was required for construction of the dams and installation of land-treatment measures above the dams (table 13). However, about 60 percent of the benefits resulting from these improvements occurred on lands below the structures.

Table 11.--Computed benefits from prevention of land damage from gullying in sample areas, Honey Creek Watershed, Iowa, 1955-60

Item	Unit	Sample areas				
		A-2	A-4	E-1	F-1	I-1
(1) Land in sample	Acre	178	221	282	722	309
(2) Annual land damage prevented	do.	.102	.353	.404	.381	.675
(3) Gross income per acre	Dollar	65.49	69.32	48.89	36.17	22.35
(4) Loss in gross income prevented	do.	5.88	21.65	16.52	10.73	9.69
(5) Cash operating costs	do.	1.47	5.41	4.13	2.68	2.42
(6) Adjusted gross income	do.	4.41	16.24	12.39	8.05	7.27
(7) Returns to land, less taxes	do.	1.32	4.82	3.72	2.41	2.18
(8) Real estate taxes	do.	.15	.54	.41	.27	.24
(9) Returns to labor, capital, and management	do.	2.94	10.88	8.26	5.37	4.85
(10) Present worth, line 9 1/	do.	12.94	47.87	36.34	23.63	21.34
(11) Present worth, line 7 2/	do.	22.00	80.33	62.00	40.17	36.33
(12) Present worth, line 8 3/	do.	5.00	18.00	13.67	9.00	8.00
(13) Present worth, line 7 4/	do.	22.00	80.33	62.00	40.17	36.33
Total, lines 10-13	do.	61.94	226.53	174.01	112.97	102.00

1/ Present worth of the annual benefit from prevention of loss of income during a 10-year adjustment period declining at a constant rate and application of 6 percent interest.

2/ Capitalized value of land returns at 6 percent interest or the market value of prevented land losses.

3/ Loss in taxes to local interests capitalized at 3 percent.

4/ This reflects the value of the loss to social interests not reflected in reduced market value of a land resource. It is derived by capitalizing the land return at 3 percent and subtracting the market value as shown in line 11.

Table 12.--Summary of total annual benefits by types attributed to sample dual-purpose structures, Honey Creek Watershed, Iowa, 1955-60

Type of benefit	Sample structures					Total sample
	A-2	A-4	E-1	F-1	I-1	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Land above structure:						
Prevention of land damage	35	128	98	64	58	383
Increased production from terrace systems	136	261	205	341	103	1,046
Total	171	389	303	405	161	1,429
Land below structure:						
Reduction of crop damage	28	35	45	114	49	271
Changed use of flood plain	40	49	63	162	69	383
Reduction in road damage	113	140	180	460	196	1,089
Increased production from terrace systems	105	0	84	24	28	241
Tax base and public interest in productivity	27	98	76	49	44	294
Total	313	322	448	809	386	2,278
Grand total	484	711	751	1,214	547	3,707

Table 13.--Cost of project measures installed in sample areas, Honey Creek Watershed, Iowa, 1955-60

Kind of measures and location	Sample areas					Total
	A-2	A-4	E-1	F-1	I-1	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Land above structures: 1/						
Structure	10,400	14,000	17,000	17,808	16,407	75,615
Land treatment	44	249	507	1,418	1,017	3,235
Total	10,444	14,249	17,507	19,226	17,424	78,850
Land below structures:						
Land treatment	132	10	675	324	124	1,265
Total costs	10,576	14,259	18,182	19,550	17,548	80,115

1/ Includes contract cost of installing dual-purpose structures.

The improvement in wildlife habitat associated with the dual-purpose structures stimulated an increase in fishing and hunting. Local reports indicate an annual visitation of 1,650 fishermen to the reservoirs. Visits for hunting also increased approximately 1,060 during the evaluation period. The visitor days of fishing averaged 22 per surface-acre of water.

Conservation Benefits

For evaluation purposes, conservation benefits are limited to the increased net returns to farm operators from land-treatment measures installed between 1955 and 1960, inclusive. The benefits are expressed as average annual returns expected from the cumulative number of measures during the period. The number and kinds of land-treatment measures recommended in the project work plan and accomplishments in their application through 1960 were shown in tables 1 and 2.

Measures directly involving terrace systems were included in the evaluation of benefits from dual-purpose structures. As mentioned earlier, the dual-purpose structures enabled the establishment of terrace systems by providing stabilized waterways for outlets. The sample area of 2,136 acres (1,712 acres above structures and 424 below) affected by structures is equivalent to 27.4 percent of the total watershed requiring application of terrace systems. Based on the rate of increased returns from terracing in the sample area, the total benefit of this type for the watershed would be $4,700.

Recommended land use adjustments included shifts of 476 acres of cropland to pasture and woodland, 131 acres of pasture to woods or wildlife, and 710 acres of pasture to crops. The net effect of these adjustments, including minor shifts in idle land, would have increased cropland 4.8 percent and decreased pastureland 13.2 percent. Had these changes occurred, value of production undoubtedly would have been materially increased (assuming no change in cropping patterns and no differences in prices received). For the sample area of 2,136 acres, the increased returns in 1960, after deducting cash operating costs, would have approximated $2,500. Projected to the watershed area affected, the return would have been about $9,100. However, land use in the sample areas during 1951-60 did not correspond with the above changes.

Changes in land use from the averages in 1951-54 indicate significant reductions in total crops and increases in pasture. However, the record shows general increases in corn and soybeans and decreases in small grain and hay. The direction of land use trends, as shown in table 14, differs for those lands in capability classes I, II, and III and those of classes IV and VII. In the latter group, the relative decline in crops was greater than that which occurred in the class I, II, and III group. Also, corn and soybeans declined on the more erodable soils, in contrast to a sharp increase on the erosion-resistant soils. Idle and Soil Bank lands show large increases in both land groups. The relative change, however, is higher in the class I, II, and III group. Taking idle land, Soil Bank land, and crops as a whole, the decline in acreage between the base years and succeeding years was relatively low.

Annual values of crop and pasture production reflect the net changes in land use, but the influence of yield variability seems to be more pronounced. Values of production by years from 1951 to 1960, based on (1) actual yields and projected long-term prices and (2) average yields and projected long-term prices, are listed below.

	Actual yields	Average yields
1951-54	$78,800	$84,200
1955	79,700	83,300
1956	72,200	82,400
1957	96,800	92,000
1958	95,100	84,100
1959	83,600	80,100
1960	96,400	89,200

Values of production in 1957-60 were considerably higher than in the preceding years. In addition to the larger acreage of higher valued crops, these differences were also due to higher yields. On the basis of average yields, only the years 1957 and 1960 depart from a generally stable value of output. The trend in land use (table 14) indicates corn and soybean acreages in these years 37 percent and 41 percent higher than the 1951-54 acreages.

Sample farms were also studied to determine changes in land use, production, and specified farm practices between 1954 and 1960. For these purposes, schedules of farm operations were obtained for 1954 and 1960 from 22 farmers. Total land in all farms decreased only 12 acres; however, changes occurred on 6 units--acreage decreased on 4 and increased on 2. Four of the operators, managing a total of 568 acres, placed all of their lands except 50 acres of pasture in the Soil Bank. These 4 farms are not included in the following summaries and analysis of data.

The volume of farm business on the 18 operating farms increased substantially between 1954 and 1960. This is indicated by the use of land and numbers of livestock, shown in tables 15 and 16. Value of crop production rose from $26,300 in 1954 to $59,100 in 1960. This is net of all costs other than labor and land. Larger acreages of corn, soybeans, and hay and an increase in average corn yields from 38 bushels to 69 bushels and alfalfa yields from 1.6 tons to 2.4 tons--all contributed to the more than doubled crop income. A significant increase in livestock income also occurred. Allowing for all production costs except labor and capital inputs, livestock returns were $48,300 in 1954 and $69,100 in 1960. Both crop and livestock production costs and livestock returns were computed at rates developed by Iowa State University.10/ Since the same prices and rates of production are used in both years, as well as identical costs and rates of all inputs, the

10/ Suggested Costs and Returns for Use with a Budgeting Procedure in Farm and Home Management. Iowa State Univ., Coop. Ext. Serv., Ames, Iowa.

Table 15.--Land use of 18 sample farms, Honey Creek Watershed, Iowa, 1954 and 1960

Use of land in farms	1954		1960	
	Acres	Percent	Acres	Percent
Corn	552	17.6	680	21.8
Soybeans	117	3.7	147	4.7
Small grain	450	14.4	188	6.0
Hay	531	17.0	575	18.5
All crops	1,650	52.7	1,590	51.0
Improved pasture	346	11.1	697	22.4
Permanent pasture	953	30.5	670	21.5
All pasture	1,299	41.6	1,367	43.9
All other land	179	5.7	159	5.1
Total	3,128	100.0	3,116	100.0

Table 16.--Livestock enterprises of 18 sample farms, Honey Creek Watershed, Iowa, 1954 and 1960

Livestock enterprises	1954	1960
	Number	Number
Dairy	72	75
Beef cow-calf sold	102	187
Beef cow-calf fed	35	21
Steers fed (yearling)	124	134
Steers fed (calf)	42	192
Sow and litter	145	232
Ewe and lamb	138	145
Hens	4,360	3,125

gain of $20,800 ($69,100 minus $48,300) in livestock income reflects the change in livestock numbers and increased forage production. The largest increases in numbers of livestock occurred in the beef cow-calf enterprise and in the steers fed and sow and litter enterprises. The dairy and sheep enterprises were relatively constant.

The difference in farm income for the two periods was $53,600. Lack of sufficient data in the analytical structure precluded isolation and quantification of the numerous variables which contributed to this increase. However, due to the accelerated land-treatment program and expanded technical assistance made available, it can be safely assumed a portion of the gain resulted from the watershed project.

Differences in weather, demand for agricultural products, prices of farm products and costs, along with other influences--all had their impact on the income changes depicted above. However, several changes in land use and farming practices planned as part of the watershed project were noted from the two sets of records for the 18 farms, taken 6 years apart. The large gains in income may be credited to a complex of factors among which project measures are a part. Based on available data, it is not feasible to completely separate the effects of the latter measures from the complex.

On the 18 farms, land-treatment measures installed between 1954 and 1960 cost $7,000, averaging $2.24 per acre of all land in farms. Among the major improvements were included 257 acres of pasture improvement, 76 acres of waterways, 7.7 miles of terraces, 204 acres of contouring, and 1.6 miles of diversions. As noted among the shifts in land use, improved pasture changed from 27 percent of the total pasture in 1954 to 51 percent in 1960. The resultant gains in forage, along with more than doubled corn production, no doubt were favorable to the large increase in livestock.

The proportion of all cropland used for corn and soybeans in 1954 and 1960 changed from 40 percent to 52 percent. Increased use of contouring, terracing, and related practices, accompanying the greater intensity of land use, increased crop yields and reduced soil erosion. The value of the improved pastures obviously was dependent upon many factors, among which the following may be listed: The extent of utilization, the kind and quality of livestock grazed, prices of livestock and livestock products, and the cost of alternative feeds. Sufficient data are not available to appraise the influence of these factors in estimating the value of increased forage. The increase in livestock numbers and the assumption of average prices, however, are evidence that the larger quantities of forage were profitable.

Based on pasture acreage, quality of pasture, and livestock grazed, reported by operators of the 18 farms surveyed, the number of animal-unit-days grazed increased about 27,000 between 1954 and 1960. Based upon an equivalent price of standing hay, the increased grazing would be valued at approximately $4,300. For the Honey Creek Watershed, assuming representativeness of the sample farms, the total benefit from this improvement would be $10,000.

RECOMMENDATIONS

Appraisal of our experience in evaluating the Honey Creek Watershed Project in operation, and of the results shown in this report reveal possible changes in evaluation techniques and planning methodology appropriate for further exploring. One of these changes involves flood damages to growing crops.

Damaging floods occurred in Honey Creek Watershed each year of the evaluation period. Between April and November, there were 2 such floods in 1956, 3 in 1957, 6 in 1958 and 1959 each, and 4 in 1960. Information obtained annually by interviews from operators of flood-plain land indicated the major effect of flooding to be reduced crop yields. Land use and yield data for flooded and nonflooded fields permitted a reasonable estimate of "flood" and "flood-free" yields. However, enumerators had little success in determining the separate influence of individual floods on yields. Current methods of estimating average annual flood damages that rely on the aggregation of the separate effects of specific floods would seem to be poorly adapted to flood plains where flooding occurs several times in one growing season. It would appear appropriate to undertake development of an evaluation procedure for these circumstances that would place greater reliance on the measurement of cumulative effects of a pattern of floods. This might involve effects on land use as well as yields and costs of crop production.

Techniques for evaluating the effects of installed structures for gully stabilization probably should include the use of check devices. This would involve the observation of uncontrolled gullies in similar situations. The appraisal of land loss and depreciation prevented by an installed system of control, using the methodology employed in this evaluation, is subject to the same uncertainties as those encountered in pre-installation methods of evaluation. The latter methods might be more appropriate for _ex post_ appraisals if the meteorologic variables are taken from actual records of the evaluation period.

Experience gained from this study indicates weaknesses in the study techniques employed for evaluating yield responses of land-treatment measures including terraces, field diversions, terrace outlets, and farm waterways. Neither the farm surveys nor the annual records of sample fields were sufficient for this purpose. Further account needs to be taken of differences in soils, weather, and farm management. Also, in view of the relatively small increases in expected yields, farmers' yield estimates are not sufficiently accurate.

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